Arnold Schwarzenegger
Governor

COOL-COLOR ROOFING MATERIAL ATTACHMENT 12: TASK 2.7.2 REPORTS - MARKET PLAN

PIER FINAL PROJECT REPORT

Prepared For:
California Energy Commission
Public Interest Energy Research Program

Prepared By:
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A Proposed Marketing Plan:
Deployment of Cool-Colored Roofing Materials

An Industry, LBNL and ORNL Collaborative Effort

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Executive Summary

The California Energy Commission (CEC) has dramatically advanced the technology of non-white "Cool Roofs" that exploit complex inorganic paint pigments to boost the solar reflectance of clay and concrete tile, painted metal, and asphalt shingle roofing. The project has successfully developed several non-white cool-colored roof products for sloped roofs over the past three years and has shown positive energy savings in residential field tests demonstrating pairs of homes roofed in concrete tile, painted metal and asphalt shingles with and without cool pigmented materials. Without further efforts, the accomplishments achieved by the CEC in its "Cool Roofs" Public Interest Energy Research (PIER) project will creep into the marketplace over the next several decades, slowly bringing the significant energy, cost, smog and carbon savings that the technology promises.

Near the end of the CEC project, the project's 16 industrial partners discussed their needs to further develop and successfully market their residential cool roofing products. Their recommendations and requests are summarized in Table 1.

The opportunity exists to rapidly accelerate the uptake of cool roofing materials. First and foremost, residential cool roofs need to be credited and recommended in the state's Title 24 standards that primarily determine what products are used in the construction of new houses and major remodels. Second, more cool materials for all residential (and commercial) sloped roofing systems must be available and appropriately labeled. Third, the application of appropriate labels on roofing products must become universal. Fourth, architects, designers, builders, roofing material distributors and retailers, and consumers need to learn of the availability and benefits of using cool roofing materials. Fourth, California utilities and the state government can further influence the selection of cool roofs through innovative incentive and rebate programs to accelerate their market penetration. Finally, market penetration can also be accelerated by enhancing the credibility of retailer and utility marketing claims through large-scale demonstrations of cool roofs to consumers, developer, designers, and roofing contractors.

We therefore define a market plan for industry/national labs collaborative efforts to help the CEC in deploying cool-colored roofing. The plan focuses on six parallel initiatives: 1) regulate, 2) increase product selection, 3) label, 4) educate, 5) provide incentives and, 6) demonstrate performance.

Table 1: Industry needs to successfully market their cool roof product

Assistance requested in marketing cool roofs	**Industry partner requesting assistance**
Continuing education for design build firms, architects, utility consumers, construction professionals and homeowners integrated into seminars offered by the CABEC.	Steelscape, BASF, Custom-Bilt, Shepherd
Software to estimate the cooling energy savings and peak demand reduction achieved by installing cool roofs on specific buildings	Steelscape, BASF, Custom-Bilt, Ferro, Elk, ARC
Monitoring solar reflectance and color change of the materials installed at the California weathering sites	Steelscape, BASF, Custom-Bilt, ISP, Ferro, Elk, ARC
Monitoring solar reflectance, color change, and thermal performance of materials at ORNL test facilities and the Sacramento test homes	Steelscape, BASF, Custom-Bilt, ISP, Elk, Ferro, ARC
Expanding the cool coating database	Steelscape, BASF, Custom-Bilt, ISP, Ferro, Shepherd, 3M
Large-scale demonstration of cool roofs	Steelscape, BASF, Custom-Bilt, ISP, Ferro, Elk, ARC
Predictive software for design of cool coatings	Steelscape, BASF, Custom-Bilt, ISP, Ferro, 3M
Research to increase reflectivity and reduce costs	ISP, Ferro, Elk, 3M, Shepherd, ARC
Tools to accurately measure solar reflectance	ISP, Elk, 3M, ARC
Calculations of weathering benefits of cool roofing	ISP
Identification of new materials and techniques	ISP, Ferro, 3M
Determination of the relationship between granule and ultimate shingle reflectances	3M
Acceleration of cool roof rating criteria by CRRC and Energy Star	3M

1. REGULATE: Modify California Title 24 Standards (2008) for non-residential sloped roofs and residential low-sloped/sloped cool roofs

California Title 24 standards have been an effective way to promote and market cool roofing materials. In January 2001, the California Title 24 adopted a measure to credit buildings that install cool roofs. In November 2003, the Energy Commission approved a proposal to upgrade Title 24 standards by making cool roofs a prescriptive requirement for low-sloped roof non-

residential buildings. This revision to the standards will be effective on October 2005. During the 2005 cycle of Title 24 upgrades, cool materials for steep-sloped roofs were scarce. Thanks to the current effort and leadership of the Energy Commission, now several manufacturers have developed cool colored materials for steep-sloped roofs. The California utilities, the PAC, industry partners, and the national labs (both LBNL and ORNL) are in full agreement that we shall proceed with efforts to develop proposals to upgrade Title 24 standards to adopt cool roofs as prescriptive requirements for sloped-roof non-residential, low-sloped-roof residential, and steep-sloped roof residential buildings.

With the Pacific Gas and Electric Company's (PG&E) and the Energy Commission leaderships, efforts are well underway to perform the required analyses to upgrade the Title 24 standards. PG&E is sponsoring work to upgrade the non-residential (both low-sloped and steep-sloped roof) buildings. The Energy Commission is sponsoring the work to upgrade the residential (both low-sloped and steep-sloped roof) buildings. The work plans for the non-residential and residential cool roof Title 24 upgrade is provided in Attachments B and C.

It has been claimed that municipalities (cities, towns, villages, and boroughs) do not require permits for residential re-roofing projects. Since the re-roofing market is typically four times larger than the new-construction roofing market, programs developed for California should have a strong component to address the re-roofing of existing homes. Hence, there is a need to work with the municipalities to ensure that ordinances are in place for compliance with California Title 24 standards in retrofit applications.

2. INCREASE PRODUCT SELECTION: Continue development work with manufacturers of cool-colored materials to deploy their products

The ongoing CEC-sponsored project has brought 16 roofing industry partners together to develop cool-colored roofing materials. Several other leading manufacturers of cool roofing products would also like to join this CEC-sponsored collaborative research. The project has made significant advances in developing cool colored concrete tiles, clay tiles, and metal products. Development of cool shingles has proved to be more challenging and requires continued support to bring cool shingles to market. The following are some activities that manufacturers have asked for help from the national labs in developing and marketing new cool materials.

Development and marketing of improved cool materials

During the course of the current CEC-sponsored project, the granule manufacturers have developed cool colored granules with solar reflectance of 0.10 to 0.15 higher than standard products of the same color. Furthermore, many of these products are not yet economically viable. The granule manufacturing partners (ISP Mineral, 3M, and CertainTeed) have asked for continued support from the Energy Commission and national labs to improve the reflectance of their granules using the bilayer technique in such methods that the production cost is further reduced. The granules from these manufacturers will be available to Elk, GAF and others to produce cool shingles at competitive prices. Other industry partners (specifically MonierLifetile and Hanson Tile) have asked for similar support for improving the reflectance of concrete tiles using the bilayer technique.

Measurement of solar reflectance at manufacturing plant

The manufacturing partners, particularly Elk, GAF, 3M, ISP Minerals, CertainTeed, MonierLifetile, Hanson Tile, and MCA Tile, on many occasions have stated that the current ASTM standards have serious limitations for measuring solar reflectance of variegated roof materials or roofing materials with three-dimensional geometry. While ASTM standards E903 and C1549 allow measuring reflectance of small roof areas (areas of less than 1" in diameter), ASTM standard E1918 is for measuring solar reflectance of larger surfaces (areas larger than 10' in diameter). Hence, measurements by E903 and C1549 are not suitable for variegated and corrugated suitable and performing measurements for large samples can be cumbersome. Our industry partners, for quality control of their products, need to have instruments with which can measure the solar reflectance of roofing materials at their production plants. This would accelerate product development, and facilitate quality control in future production lines.

Correlation between the reflectance of granules to that of the shingles

Roofing granules cover at least 97% of area of roofing shingles. Hence, the optical properties of roofing shingles are primarily defined by those of the granules. The granule industry partners (ISP Minerals, 3M, and CertainTeed) would like to develop a method to relate the solar reflectance of a roofing shingle to that of its granules. A strong correlation between granule and shingle solar reflectance may be acceptable to Cool Roof Rating Council (CRRC), potentially allowing the granule manufacturers to obtain CRRC labels for their products, then transfer the labels to shingle products.

Cool roof energy saving calculator for contractors

Our industry partners have repeated mentioned that a "cool-roof saving calculator" will be extremely useful to the manufacturers, distributors, and roofing contractors in their marketing of cool roofing products. Currently, there are two models available that predict different saving potentials: DOE model (developed by ORNL) and EPA model (developed by LBNL). The national labs (ORNL and LBNL) need to work together to develop an integrated calculator for estimating the effect of the roof solar reflectance on heating and cooling energy use. The algorithm developed for the calculations of savings need to be utilized in a web-based calculator (and a PC-based version) with which roofing contractors and distributors can estimate the cooling energy savings and peak demand reduction achieved by installing cool roofing on specific buildings. This would allow the manufacturers of cool roofing materials to use the benefit of cool roofs to help market their products.

Aging and evaluation of cool roofing products in California weathering site

Manufacturers are constantly developing new and improved cool roofing materials. To characterize the long-term performance of the cool materials, we need to continue to monitor the solar reflectance and color change of the roofing materials installed at the California weathering sites in order to accommodate new products as they are developed. A database of the optical performance of the cool roofing materials will be extremely useful to both manufacturers, consumers, policy makers, and the Cool Roof Rating Council.

Cool roof product monitoring and evaluation at labs

As new products are becoming available, the characterization of their performances is necessary for ultimate deployment and marketing of the products. The manufacturers have submitted many samples for performance monitoring at the ORNL test facilities. The manufacturers would like to continue monitoring the solar reflectance, color change, and thermal performance of roofing materials installed and new materials to be installed at ORNL test facilities. The results of these characterizations can be integrated in the cool materials database.

Assist manufacturers of cool roofing products with CRRC labeling

Many roofing manufacturers have not applied for CRRC labels. The manufacturers would like to join CRRC, and CRRC is anxious to expand their manufacturing members. In a fully coordinated effort, we need to work with the industry and CRRC to understand technical reasons for the manufacturers' delays and provide them technical assistance needed to obtain CRRC labels.

This task will build on the simulation efforts outlined in Task 1 by developing detailed and customized estimates of energy savings and peak demand reductions for several detailed prototypical residential and high-sloped commercial buildings. In this task, we will

- perform detailed and calibrated DOE-2 simulations of several residential, commercial, and industrial buildings for all climate regions in California,
- develop a database of savings and perform cost/benefit analyses for various cool roofing types, customized for California utilities' rebate applications,
- work with Southern California Edison and PG&E in designing innovative and effective consumer incentive and emerging technologies programs.

3. LABEL: Facilitate labeling of cool roofs through CRRC

The manufacturing partners consider the Cool Roof Rating Council (CRRC) organization and labeling as an effective method for marketing cool roofing materials. They would like the national labs to support the CRRC in its effort to accelerate market penetration of cool roofing materials via the following activities:

- Help CRRC and roofing manufacturers to overcome and resolve technical issues that arise in implementation of the CRRC label program.
- Provide technical information that helps manufacturers develop brochures and educational kits for distribution at trade shows and roofing materials distribution centers (see Attachment D as an example).
- Develop a web site which manufacturers can educate their customers, contractors, and designers

4. EDUCATE: Tell the California Building Community and Homeowners about "Cool Roof" Benefits

This task will be accomplished primarily through the California Association of Building Energy Consultants (CABEC) (http://www.cabec.org/). CABEC currently hosts classes and seminars on the latest technologies in heating, ventilation and air-conditioning, windows and air distribution

systems, but offers little training that addresses "Cool Roofs" because of the dearth of information. We propose to enhance the roofing component of CABEC's training program with emphasis on the benefits of cool roofs.

The CEC should integrate "Cool Roof" training into building efficiency seminars already hosted by the public utilities and taught through the existing framework of the California Association of Building Energy Consultants (http://www.cabec.org/). The CABEC hosts training seminars on the Energy Efficiency Standards for Residential and Nonresidential Buildings (Title 24, Part 6 of the California Code of Regulations) that communicate the new 2005 building compliance rules, which take effect October 1, 2005. Part of the new compliance rules call out prescriptive requirements for the minimum solar reflectance and thermal emittance for commercial low-slope roofs, and 2008 rules will focus on steep-slope roofs. Therefore, "Cool Roof" training must be directly integrated into these seminars and address Title 24 roof legislation that architects and design build firms[1] must know. Some of the class topics presently taught through the CABEC includes high performance glazing and radiant barrier roof sheathing, duct testing and procedures that verify home energy usage (an example, the Home Energy Rating System). However, training materials are sparse on the advantages of "Cool Roofs." Several one-day training courses are needed for contractors and designers in the application of cool roofing products in California, and can be offered at the energy centers of PG&E, San Diego Gas and Electric, Southern California Gas, Southern California Edison and Sacramento Municipal Utility District.

Additional training is needed to explain the implications of cool roofs on time of demand metering. Seminars should be offered explaining potential rebate incentives for the builder. Mortgage incentives for the homeowner choosing a cool roof should be offered and information provided on the impact of sustainable cool roofs on the resale value of homes. Training is also needed to help builders and construction crews improve installation practices, which will cut construction costs, especially for tile and painted metal roofing. Success of the educational program requires the complete buy-in by the public utilities and a commitment to communicate through articles published in trade association magazines[2], newspaper articles and each respective utilities newsletter that they broadcast to the community of California builders within their region. Large-scale demonstrations of cool roofs would certainly help demonstrate to utilities, architects, builders and homeowners the energy saving potentials from which the California utilities and the state government can confidently offer incentives appropriate to the level of savings afforded by cool roofs.

5. PROVIDE INCENTIVES: Develop incentive programs for cool colored roofs

Utility-sponsored programs have been a proven and an effective approach in introducing innovative energy technology products to California markets. The rebates are payments for acquiring larger public benefits that aren't captured by the private marketplace. To develop rebate programs, utilities require accurate and customized estimates of energy savings and peak demand reductions for all roofing systems and building types in all climate regions within their service territories. To develop and market roofing products that comply with utility rebate

[1] Metal Constructions census revealed that 67% of metal roof projects are done by design build firms and 52% of metal roof projects involve architects.

[2] California Builders magazine, Professional Roofing, Western Roofing, Metal Roofing, RCI Interface, Metal Architecture, Metal Construction News, Metal Home Digest, etc.

programs, manufacturers need this same information. The utilities are offering rebates for home improvements that include insulation, improved water heaters and higher performance windows. Cool roofs should be a part of the utilities rebate program. A hypothetical rebate of $0.10 per square foot of roof may represent only about 5% of the total installed cost of the roof to the consumer (about $2 per square foot of roof). However, the same rebate of $0.10 per square foot might increase the net profit to the contractor by about 50%. Also, the production of cool roofing materials can be encouraged by offering incentives to manufacturers so that they can market cool roofing materials competitively.

Countrywide Home Mortgage Loans, PHH Mortgage Services and Chase Manhattan offer Energy Star mortgages for Energy Star compliant homes. The mortgages include discounted interest rates, cash back after closing and higher appraisal values on the resale value of homes that can demonstrate lower utility bills. The Appraisal Journal (Oct. 1998 & 1999) reported that "the market value of a home increases $20 for every $1 decrease in annual utility cost." Offering mortgage incentives to homeowners would also foster the selection of cool roof products.

It is important to note that an Energy Star labeled roof is not part of the requirements for an Energy Star home (Kriner private conversation with Rachel Schmeltz and Steve Ryan of the EPA), because the EPA believes there are no Energy Star labeled products available for steep slope roofing. Implementing our market strategy will correct this misconception and open the opportunity for including cool roof incentive in Energy Star mortgages.

6. DEMONSTRATE PERFORMANCE: Arrange large-scale demonstrations in each utility service area to showcase cool-colored roofing materials

Demonstrations of new products can be a powerful tool to showcase the performance of cool roofs to consumers, developer, designers, and roofing contractors. The manufacturers would benefit from a community-wide demonstration by publicizing their products to the market (consumers, developers, designers, utilities). Proving product performance will reduce consumer risk and uncertainty. The utilities will benefit by validating the performance of the products which will make cool roofs more attractive to developers and homeowners.

We have been discussing and planning development of large-scale demonstrations with many of our partners to showcase cool roofing materials in communities with hundreds of homes. Attachment E presents a recent plan developed for demonstrations in Southern California. The materials to be demonstrated are painted metal. Similar demonstrations are needed for cool shingles or clay and concrete tiles. The goal is to initiate two demonstration projects, one in northern and one in southern California. The monitoring cost of the demonstrations will be cost-shared with utilities. The developers would pay for the roofing, which the manufacturers would make offer at costs comparable to those of their standard products.

Conclusion — Market Potential

California's ability to meet peak electricity demand in the future is one of the primary electrical issues confronting its public utility companies. The CEC has stated that hot summer temperatures can drive up peak electrical demand as much as forty-five percent, and California is increasingly relying on out-of-state electrical supplies. Residential air-conditioning loads represent almost 14

percent of the summer peak demand; the equivalent of over 7,000 MW of peak capacity during a hot California summer day. To exacerbate the problem, significant new housing growth in both the near and long term will occur in California's urban areas and hot inland regions. "Cool Roofs" can provide a significant part of the solution to California's dilemma. The market opportunity therefore exists for a "cool roofs" business venture. What is needed is the reasoned faith derived from the research and the fortitude to act upon the results.

This report outlines six market interventions available to the CEC to reduce or eliminate barriers that slow the market penetration of cool roofing products into the residential housing market. These interventions reach manufacturers, distributors, retailers, architects, designers, builders, utilities, and consumers. All are useful in accelerating the use of cool roofing materials in California's residences. If they are implemented, California will benefit by reducing cooling energy use (by about 1 TWh per year; worth about $100 M per year) and peak air conditioning demand (by about 1-2 GW), and improve ozone air quality (estimated at about $200 M per year).[3]

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[3] We estimate that over 70% of the residential buildings in California have colored shingle roofs with reflectivities of about 10% - 20%. We estimate that about 50% of the approximately 12 million single-family residences are air-conditioned. The average AC peak demand for each house is about 1.5 kW; hence, the contribution of residential AC demand to total utility demand is about 8 GW. The air-conditioning systems of many of these houses (particularly those located in coastal areas) usually do not operate except on a few extremely hot days. Application of cool colored roofs in residential sector can significantly reduce this peak demand (we estimate on the average by 15%-30%, or 1.2GW to 2.4GW). The annual energy savings is estimated at about 1 TWh.

Attachment A

In May 2002, the California Energy Commission (Energy Commission) sponsored a research project to develop "cool" nonwhite roofing products that could revolutionize the residential roofing industry. An initial collaboration between Lawrence Berkeley National Laboratory, Oak Ridge National Laboratory, and eight roofing manufacturing rapidly grew to include 16 industrial partners (see Table A.1). Seven other manufacturers and roofing organizations have joined the project's advisory committee (see TableA.2).

Table A.1. List of manufacturing industry partners

1. 3M Industrial Minerals, Pittsboro, NC; www.scotchgard.com/roofinggranules
2. Akzo-Nobel, Macungie, PA; www.akzonobel.com
3. American Rooftile Coatings, Fullerton, CA; www.americanrooftilecoatings.com
4. BASF Industrial Coatings, Mount Olive, NJ; www.ultra-cool.basf.com
5. CertainTeed, Valley Forge, PA; www.certainteed.com
6. Custom-Bilt Metals, South El Monte, CA; www.custombiltmetals.com
7. Elk Corporation, Dallas, TX; www.elkcorp.com
8. Ferro Corporation, Cleveland, OH; www.ferro.com
9. GAF Materials Corporation, Wayne, NJ; www.gaf.com
10. Hanson Roof Tile, Fontana, CA; www.hansonrooftile.com
11. ISP Minerals Incorporated, Hagerstown, MD; Tel. (301) 733-4000
12. MCA Tile, Corona, CA; www.mca-tile.com
13. MonierLifetile LLC, Irvine, CA; www.monierlifetile.com
14. Owens Corning, Granville, OH; http://www.owenscorning.com/around/roofing/Roofhome.asp
15. Shepherd Color Company, Cincinnati, OH; www.shepherdcolor.com
16. Steelscape Incorporated, Kalama, WA; www.steelscape-inc.com

Table A.2. Industry Representation on the Project Advisory Committee

1. DuPont Titanium Technologies
2. National Roofing Contractors Association
3. Cedar Shake and Shingle Bureau (CSSB)
4. Cool Roof Rating Council (CRRC)
5. Cool Metal Roofing Coalition
6. Roof Tile Institute
7. Asphalt Roofing Manufacturers Association

Cool Roofs for non-Residential Steep- and Low-Sloped Roofs Buildings

Background:

In 2003, the Pacific Gas and Electricity Company (PG&E) submitted a proposal to California Energy Commission (CEC) to amend the existing Title 24 standards by requiring cool roofs for California low-sloped non-residential buildings. With the sponsorship of PG&E, LBNL prepared the technical document (CASE study) to support the modifications to Title 24 standards. In November 2003, CEC approved the CASE proposal and amended the Title 24 to adopt "cool roofs" as prescriptive requirement for low-slope roofs in non-residential buildings. CEC has also shown a strong interest to expand the current scope of the proposal to cover low- and steep-sloped roofs residential buildings.

PG&E reviews existing codes in the California Code of Regulations, Building Energy Efficiency Standards, Title 24, Part 6 (hereinafter Title 24) typically every three years. It reviews current practices with the latest and/or promising design and technological advances in residential and nonresidential construction while ensuring cost effectiveness for consumer. PG&E is conducting the following activities in developing and supporting a Title 24 code enhancement proposal for steep-slope nonresidential cool roofs, for California's 2008 building code upgrade cycle. The main objectives of this proposal are to develop a CASE study for application of cool roof on non-residential sloped Roofs and conduct research on incorporating degradation of cool roofing materials into Title 24.

Scope of Work:

The Work to be performed by LBNL under the Contract shall consist of the following:

- developing Codes and Standards Enhancement studies (hereinafter "CASE Studies")
- conducting market research and consensus-building workshops
- conducting research on incorporating degradation of cool roofing materials into Title 24
- advocating adoption of the CASE study proposals during CEC's public rulemaking process
- ensuring that PG&E's Code amendment proposals are correctly incorporated into the CEC Title 24 documents.

LBNL will perform all the Work necessary to complete each task under the Contract as defined below and shall provide deliverables as required and on the due dates.

CASE Studies for Cool Roofs:

LBNL shall collaborate with PG&E Project Manager to develop the following code enhancement proposal for California's 2008 building code upgrade cycle: the application of cool roofs to non-

residential steep-sloped roof buildings. The CASE study, as described in the workplan, will recommend adoption of specific revisions to the California Code of Regulations, Building Energy Efficiency Standards, Title 24, Part 6 (hereinafter "Code**"**).

Task 1. Kickoff meeting:

LBNL shall conduct a Kick-off Meeting with the PG&E Project Manager within ten (10) business days of receiving a signed Contract. At the meeting, LBNL shall present a brief review of CASE study technical, market and stakeholder issues as they relate to the potential for future adoptability. Adoptability criteria shall include a general assessment of technical and economic feasibility, market readiness by 2008, and stakeholder support. LBNL's presentation shall be an overview of issues pertinent to the CASE Study. Following the meeting, LBNL shall produce an e-mail summary of the meeting including significant issues discussed and action items.

DELIVERABLE/DUE DATE:

1) Kick-off meeting presentation two business days prior to the kick-off meeting
2) E-mail summary three days after the kick-off meeting

Task 2. CASE Study Work Plan:

Following the kickoff meeting, LBNL shall develop a work plan that address the requirements defined in Task 3.1. The work plan shall include, but not be limited to:

- Identification of issues or barriers unique to development of the CASE Study and/or implementation of the proposed measure
- Establishment of deliverables (tasks and subtasks), that ensure all items in Task 3 are adequately addressed. The number of tasks and subtasks shall reflect the Work needed to be performed and clearly convey the status of each Case Study.
- Budget and schedule for each task or subtask
- The number of anticipated stakeholder meetings to review the progress of each CASE Study.

DELIVERABLES/DUE DATES:

1. DRAFT WORK PLAN: LBNL shall submit a draft work plan to PG&E Project Manager for review, comments and approval. Submittal of draft work plans to be scheduled by PG&E Project Manager and Consultant.
2. FINAL SUMMARY REPORT: LBNL shall incorporate PG&E Project Manager's comments and resubmit the final work plans to PG&E Project Manager five (5) business days after receipt of comments.

Task 3. Develop CASE study:

LBNL shall coordinate the development of the CASE Studies with PG&E, CEC, industry representatives, and other stakeholders.

Task 3.1. CASE study for steep-sloped nonresidential roofs.

LBNL shall develop a CASE report for sloped-roof nonresidential buildings. The elements of this task include:

A. Development of prototype buildings for sloped-roof nonresidential buildings. In this subtask, we will use the CEC existing residential prototypes. We will modify and revise the prototypes as necessary.

B. Collecting market share data and reviewing cool roofs application on sloped-roof nonresidential buildings.

C. Incorporating the effects of ageing on cool roof materials into Title 24.

D. Performing energy simulations to estimate savings for all California climate regions. We are planning to use DOE2 software for these calculations. The calculations will be performed for both existing and new nonresidential buildings.

E. Performing a cost/benefit analysis (both TDV and non-TDV). The analysis will be carried out for both existing and new nonresidential buildings.

F. Estimating state-wide savings. The state-wide savings will be estimated for both existing and new nonresidential buildings.

G. Preparing proposals to change the relevant sections of Title 24

H. Presenting the results and responding to comments.

DELIVERABLES/DUE DATES:

1. PRELIMINARY DRAFT CASE STUDY: LBNL will submit preliminary draft report for each CASE Study for PG&E Project Manager's review and comments as set forth in each CASE Study work plan, but not later than 180 days after Contract execution.
2. FIRST REVISION OF DRAFT CASE STUDY: LBNL will incorporate comments and resubmit draft CASE Study to PG&E Project Manager seven (7) business days after receipt of comments.

Task 3.2. Modification to Title 24 standards for ageing of low-sloped nonresidential roofs.

Currently, the Title 24 standard in its prescriptive requirements specifies the solar reflectance of new cool materials. A cool roof is defined having an initial solar reflectance of at least 0.70. In the "performance" and "over-all envelop" sections, the calculations are performed for aged solar reflectance of 0.55. The objective of this task is to perform the required research on degradation of cool roofing materials and incorporate the results into Title 24. The elements of this task include:

1. Collect field data on the solar reflectance of aged cool materials. In 2003, the Cool Roof Rating Council (CRRC) initiated a program to measure the three year solar reflectance of roofing materials in Arizona and Florida. By the summer of 2005, some of the samples have been weathered for about two years. We will visit the weathering site in Arizona and measure the solar reflectance of the 2-year old specimen. We will

analyze the data and produce a short report of the aged reflectance *vs.* initial reflectance, categorized by type of roofing materials.
2. Share the aging data with experts and solicit comments. The data will be shared with CEC and CRRC and comments will be gathered.
3. Prepare a proposal for Title 24 modification. We will incorporate received comments and prepare a proposal to modify Title 24 standards of the aged reflectance.

Task 3.3. Project update meetings and reporting:

LBNL project team members shall attend a maximum of six (6) - 2-hour meetings to present progress and issues that arise during the development of the CASE study. Meetings shall be held at PG&E facilities in San Francisco or Davis. LBNL shall prepare a memorandum after each project update meeting to address issues and concerns discussed at the meetings. LBNL shall also submit a Monthly Status Report to the PG&E Manager. The Monthly Status Report shall include work progress and comparison of budget and actual expenditures for all tasks/subtasks in the work plan, status of key deliverables, and other items as requested by the PG&E ProjectManager.

DELIVERABLES/DUE DATES:

1. MEMORANDUM: LBNL will submit Issues Memorandum to PG&E Project Manager (5) business days after each project update meeting.
2. MONTHLY STATUS REPORT: At the end of each month, LBNL shall issue a Monthly Status Report to PG&E.

Task 4. Stakeholder workshop:

LBNL shall assist the PG&E Manager with planning and conducting an industry stakeholder (consensus-making) workshop to present CASE Study findings and solicit comments from the stakeholders. The workshop shall be held at a PG&E facility in San Francisco or Davis.

Task 4.1. Workshop agenda:

LBNL shall develop the following meeting materials for review and approval by the PG&E Project Manager.

a) An agenda and a proposed list of stakeholders

b) Presentation materials than include an outline and summary of the CASE Study report

Following the workshop, LBNL shall prepare a workshop report summarizing the workshop proceedings. The workshop report shall include a list of attendees, workshop agenda and handouts, meeting minutes, outstanding issues not resolved at the workshop, and recommended actions to take with respect to issues raised. LBNL shall revise the draft workshop report based on comments provided by the PG&E Project Manager.

DELIVERABLES/DUE DATES:

1. LBNL shall submit draft workshop agenda and list of stakeholders to PG&E Project Manager at a mutually agreed schedule for review. LBNL will incorporate the PG&E Project Manager's comments, if any, and submit revised agenda three (3) business

days prior to the workshop. In addition, LBNL shall distribute agenda and Draft CASE Studies to all meeting attendees via email at least two (2) business days prior to the workshop.

2. LBNL shall develop and submit presentation materials for each CASE study to the PG&E Project Manager for review and comment at a mutually agreed upon schedule. LBNL shall incorporate the PG&E Project Manager's comments and issue presentation materials to the PG&E Project Manager two (2) business days prior to the workshop. Consultant shall provide up to 30 printed copies of the presentation materials at the workshop.
3. LBNL will prepare draft report for the PG&E Project Managers' review and approval five (5) business days after the workshop, and shall incorporate PG&E Project Managers' comments into the final workshop summary report five (5) business days after receipt of comments.

Task 4.2. Final draft case study:

LBNL will produce a Final Draft CASE Study report. The final draft report shall incorporate input including, but not limited to, outstanding issues and recommended actions identified by workshop attendees and PG&E and CEC Project Managers.

DELIVERABLES/DUE DATES: LBNL shall revise the draft CASE Study report for the PG&E Project Managers' review and comment for each CASE Study within fifteen (15) business days after CASE Study was presented at a PG&E workshop and shall incorporate PG&E Managers' comments into the Final Draft CASE Study no more than five (5) business days after receipt of PG&E Project Manager's comments.

Task 5. Support for PG&E CASE study proposals during CEC rulemaking:

LBNL shall participate in a maximum of four (4) CEC workshops or adoption hearings, and six (6) teleconferences, as requested by the PG&E Project Manager, to assist with advocacy of proposed code enhancements and to gather comments. The scope of these activities shall include both PG&E's nonresidential code change proposals and related code change proposals submitted by others.

Task 5.1. Presentation materials:

Prior to each CEC workshop, hearing, or teleconference call, LBNL shall prepare support materials as requested by the PG&E and CEC Project Managers. Support materials shall include, but not be limited to:

- CASE studies and summary presentations; and
- Ongoing research, analyses and status summary presentations.

DELIVERABLES/DUE DATES: LBNL shall prepare draft presentation materials for review and approval by the PG&E Project Manager, ten (10) business days before each CEC workshop or hearing, and shall incorporate PG&E Project Managers' comments into the final presentation

materials five (5) business days before each CEC workshop or hearing. LBNL will provide up to 50 print copies of support materials on the day of each CEC workshop or hearing.

Task 5.2 CEC workshop and summary report:

During each workshop, hearing, or teleconference, LBNL shall present materials, participate in discussions and record significant issues presented by each stakeholder, significant questions, and outstanding issues. Following each CEC workshop, hearing or teleconference, LBNL will provide a written summary report to the PG&E Project Manager. The summary report shall include, but is not limited to, links to the CEC web site where the workshop agenda and presentations are posted, information recorded (significant issues and questions) during the meetings, and recommended actions in response to questions and outstanding issues.

LBNL shall prepare draft responses to questions and issues under the direction of the PG&E Project Manager. Responses shall include, but are not limited to:

- Performing additional analysis;
- Conducting additional market research;
- Developing alternative code revision language;
- Preparing communications memoranda, e-mail comments, or other materials;
- Conducting teleconferences or stakeholder meetings;
- Revising the CASE Study; and
- Gathering or developing other materials as needed.

DELIVERABLES/DUE DATES

1. SUMMARY REPORT: LBNL will provide summary report three (3) business days after each CEC workshop.
2. RESPONSES TO QUESTIONS AND ISSUES: LBNL shall prepare draft responses for PG&E Project Managers' review and approval, and incorporate PG&E Project Managers' comments into the final responses to questions and issues. Schedule to be determined by the PG&E Project Manager and LBNL.

Task 6. Review of Title 24 documents:

LBNL shall review drafts of CEC Title 24 documents to ensure that PG&E Code amendment proposals are correctly incorporated in:

- 2008 Building Energy Efficiency Standards for Nonresidential Buildings (and related appendices);
- 2008 Nonresidential and Alternative Calculations Methods Manual (and related appendices)
- Nonresidential Manual for Compliance with 2008 Energy Efficiency Standards for Nonresidential Buildings, High-Rise Residential Buildings, and Hotels/Motels (and related appendices).

Under the direction of the PG&E Project Manager, LBNL will report the status of and describe needed changes to draft documents by performing the following:

- Conducting a detailed review of Title 24 documents focusing on text and diagrams related to code enhancements for which PG&E has made significant contributions;
- Identifying and documenting inconsistencies between Title 24 documents and PG&E's goals, as established in PG&E CASE studies;
- Proposing edits in the CEC-required format;
- Attending up to five conference calls to discuss proposed edits with PG&E and CEC staff;
- Providing edits to Title 24 documents that resolve inconsistencies; and
- Gathering or developing other materials as needed.

DELIVERABLES/DUE DATES: As requested by the PG&E Project Manager, LBNL will prepare proposed edits to Title 24 documents for review. LBNL will incorporate comments by the PG&E Project Manager to prepare final proposed edits, and submit to PG&E Project Manager and CEC staff. Schedule to be determined by PG&E Project Manager based on CEC rulemaking schedule and other deadlines.

Task 7. Final CASE studies and estimated overall impacts:

Following adoption of the 2008 standards, LBNL shall prepare a final CASE Study report documenting the initial proposal, any modifications throughout the process, and the final status of the proposal. LBNL shall review the CEC's impact analysis for 2008 standards and identify significant differences between the CEC's and PG&E's savings estimates. For each CASE study for which savings differ significantly, LBNL shall analyze differences in methodology and assumptions and either: a) recommend changes to revise PG&E CASE Study savings, or b) explain why revisions are not necessary.

LBNL shall update all sections of each Final Draft CASE Study to reflect all changes (for example, code language or savings estimates) resulting from stakeholder input during the CEC rulemaking process and differences in impact analyses.

DELIVERABLE/DUE DATE: LBNL will submit each Final 2008 CASE Study to the PG&E Project Manager for review and comment and shall incorporate comments into final document. Schedule to be determined by PG&E Project Manager and LBNL.

Cool Roofs for Residential Low- and Steep-Sloped Roofs

Background:

In 2003, the Pacific Gas and Electricity Company (PG&E) submitted a proposal to California Energy Commission (CEC) to amend the existing Title 24 standards by requiring cool roofs for California low-sloped non-residential buildings. With the sponsorship of PG&E, LBNL prepared the technical document (CASE study) to support the modifications to Title 24 standards. In November 2003, CEC approved the CASE proposal and amended the Title 24 to adopt "cool roofs" as prescriptive requirement for low-slope roofs in non-residential buildings. CEC has also shown a strong interest to expand the current scope of the proposal to cover sloped-roof non-residential buildings and low- and steep-sloped roofs residential buildings. This proposal is to develop CASE studies for application of cool roof on (1) residential low-sloped roofs and (2) residential steep-sloped roofs. A companion study sponsored by the PG&E will develop a CASE study for non-residential steep-sloped roofs.

Scope of Work:

The Work to be performed by LBNL under the Contract shall consist of the following:

- developing Codes and Standards Enhancement studies (hereinafter "CASE Studies")
- conducting market research and consensus-building workshops
- advocating adoption of the CASE study proposals during CEC's public rulemaking process
- ensuring that the Code amendment proposals are correctly incorporated into the CEC Title 24 documents.

LBNL will perform all the Work necessary to complete each task under the Contract as defined below and shall provide deliverables as required and on the due dates as agreed upon by CEC Project Manager and LBNL. A companion study sponsored by the PG&E will develop a CASE study for non-residential steep-sloped roofs. This project will closely coordinate the efforts between the projects sponsored by CEC and PG&E.

CASE Studies for Cool Roofs:

LBNL will develop two code enhancement proposals for California's 2008 building code upgrade cycle: (1) application of cool roofs for sloped-roofs residential buildings (2) application of cool roofs for low-sloped-roofs residential buildings. The CASE study, as described in the workplan, will recommend adoption of specific revisions to the California Code of Regulations, Building Energy Efficiency Standards, Title 24, Part 6 (hereinafter "Code").

Task 1. Organize a Project Advisory Committee:

The project will be carried out in direct collaboration with the industry and other national laboratories interested in cool roofs. LBNL will organize a Project Advisory Committee for the studies. The initial list of participants will include:

- Oak Ridge National Laboratory
- Florida Solar Energy Center
- Cool Roof Rating Council
- Pacific Gas and Electric Company
- Southern California Edison Company
- San Diego Gas and Electric Company and Southern California Gas Company
- California Energy Commission
- Berkeley Solar Group

DELIVERABLE/DUE DATE: **List of PAC members**.

Task 2. Kickoff meeting:

LBNL will conduct a Kick-off Meeting with the CEC Project Manager and PAC members. At the meeting, LBNL will present a brief review of two CASE Study topics for consideration of the potential for future adoptability. Adoptability criteria shall include a general assessment of technical and economic feasibility, market readiness by 2008, and stakeholder support. LBNL's presentation shall be an overview of issues pertinent to each CASE Study.

DELIVERABLE/DUE DATE: LBNL will conduct a kickoff meeting within ten (10) business days of receiving a signed Contract.

Task 3. CASE studies workplan:

Following the kickoff meeting, LBNL shall develop a work plan that address the requirements defined in Task 4. The work plan shall include, but not be limited to:

- Identification of issues or barriers unique to development of the CASE Study and/or implementation of the proposed measure
- Establishment of deliverables (tasks and subtasks), that ensure all items in Task 3 are adequately addressed. The number of tasks and subtasks shall reflect the Work needed to be performed and clearly convey the status of each Case Study.

DELIVERABLES/DUE DATES: **DRAFT WORK PLAN**.

Task 4. Develop CASE study:

LBNL will coordinate the development of the CASE Studies with California utilities, CEC, industry representatives, and other stakeholders.

Task 4.1. Development of a CASE study for steep-sloped-roof new and existing residential buildings.

In this task, we will develop a CASE report for steep-sloped-roof residential buildings. This task will include both existing and new steep-sloped-roof residential buildings. The elements of this task include:

A. Development of prototype buildings for steep-sloped-roof new and existing residential buildings. In this subtask, we will use the CEC existing residential prototypes. We will modify and revise the prototypes as necessary.

B. Coordinating activities with CEC PIER project analyzing attic performance and modeling assumptions to ensure the results of the PIER project are incorporated into the CASE studies.

C. Collecting market share data and reviewing cool roofs application on steep-sloped-roof new and existing residential buildings.

D. Performing energy simulations to estimate savings for all California climate regions. We are planning to use EnergyPro software for these calculations. The calculations will be performed for both existing and new residential buildings.

E. Performing a cost/benefit analysis (both TDV and non-TDV). The analysis will be carried out for both existing and new residential buildings.

F. Estimating state-wide savings. The state-wide savings will be estimated for both existing and new residential buildings.

G. Preparing proposals to change the relevant sections of Title 24

H. Presenting the results and responding to comments.

DELIVERABLES/DUE DATES:

1. **PRELIMINARY DRAFT CASE STUDY**: LBNL will submit preliminary draft report for the CASE Study for CEC Project Manager's review and comments.
2. **FIRST REVISION OF DRAFT CASE STUDY**: LBNL will incorporate comments and resubmit draft CASE Study to CEC Project Manager

Task 4.2. Development of a CASE study for low-sloped-roof new and existing residential buildings.

In this task, we will develop a CASE report for low-sloped-roof residential buildings. This task will include both existing and new low-sloped-roof residential buildings. The elements of this task include:

A. Development of prototype buildings for low-sloped-roof new and existing residential buildings. In this subtask, we will use the CEC existing residential prototypes. We will modify and revise the prototypes as necessary.

B. Coordinating activities with CEC PIER project analyzing attic/roof performance and modeling assumptions to ensure the results of the PIER project are incorporated into the CASE studies.

C. Collecting market share data and reviewing cool roofs application on low-sloped-roof new and existing residential buildings.

D. Performing energy simulations to estimate savings for all California climate regions. We are planning to use EnergyPro software for these calculations. The calculations will be performed for both existing and new residential buildings.

E. Performing a cost/benefit analysis (both TDV and non-TDV). The analysis will be carried out for both existing and new residential buildings.

F. Estimating state-wide savings. The state-wide savings will be estimated for both existing and new residential buildings.

G. Preparing proposals to change the relevant sections of Title 24

H. Presenting the results and responding to comments.

DELIVERABLES/DUE DATES:

1. **PRELIMINARY DRAFT CASE STUDY**: LBNL will submit preliminary draft report for the CASE Study for CEC Project Manager's review and comments.
2. **FIRST REVISION OF DRAFT CASE STUDY**: LBNL will incorporate comments and resubmit draft CASE Study to CEC Project Manager

Task 4.3. Project update meetings and reporting:

This task will be carried out in collaboration with PG&E. LBNL project team members will attend a maximum of six (4) - 2-hour and two (2) - half-day project update meetings with the CEC Project Manager and stakeholders. LBNL will present progress of each CASE Study and issues that arise during the development of each CASE Study. LBNL will prepare a memorandum after each project update meeting to address issues and concerns discussed at the meetings. LBNL will also submit Quarterly Status Report to the CEC Project Manager for review, comment, and approval. Quarterly Status Report shall include but is not limited to a brief description of the proposed standards change and objective, Work progress and comparison of budget and actual expenditures for all tasks/subtasks in the work plan for each CASE Study, and status of key deliverables.

DELIVERABLES/DUE DATES:

1. **ISSUES MEMORANDUM**: LBNL will submit Issues Memorandum to CEC Project Manager.
2. **QUARTERLY STATUS REPORT**: At the end of each quarter, LBNL will issue a Quarterly Status Report to CEC Project Manager

Task 5. CEC Stakeholder workshop:

This task will be collaborated between CEC- and PG&E-sponsored projects. LBNL will assist the CEC Project Managers with planning and conducting one (1) industry stakeholder (consensus-making) workshop to present CASE Studies findings and solicit comments from the stakeholders.

Task 5.1. Workshop agenda:

LBNL will develop a meeting agenda and a proposed list of stakeholders for review and approval by the CEC Project Managers.

DELIVERABLES/DUE DATES: **WORKSHOP AGENDA**. LBNL will submit draft workshop agenda and list of stakeholders to CEC Project Manager for review. LBNL will incorporate CEC Project Manager's comments, if any, and submit revised agenda. In addition, LBNL will distribute agenda and Draft CASE Studies to all meeting attendees prior to each scheduled workshop.

Task 5.2. Presentation material:

For each CASE Study to be presented at the workshops, LBNL will prepare draft presentation materials for CEC Project Manager's review and approval. Presentation materials shall include an outline and summary of the CASE Study report and be presented in a format agreed to or provided by CEC Project Manager.

DELIVERABLES/DUE DATES: **PRESENTATION MATERIALS**. LBNL will develop and submit presentation materials for each CASE study to CEC Project Manager. LBNL will incorporate CEC Project Manager comments and finalize presentation materials.

Task 5.3. Workshop summary report:

LBNL will prepare a workshop report summarizing the workshop proceedings. The workshop report shall include a list of attendees, workshop agenda and handouts, meeting minutes, outstanding issues not resolved at the workshop, and recommended actions to take with respect to issues raised regarding each CASE Study. LBNL will revise the draft workshop report based on comments provided by the CEC Project Manager.

DELIVERABLES/DUE DATES: **WORKSHOP SUMMARY REPORT**. LBNL will prepare draft report for CEC Project Manager's review and approval, and will incorporate CEC Project Manager's comments into the final workshop summary report.

Task 5.4. Final draft case study:

LBNL will produce Final Draft CASE Study reports. The final draft report shall incorporate input including, but not limited to, outstanding issues and recommended actions identified by workshop attendees and CEC Project Manager.

DELIVERABLES/DUE DATES: **FINAL DRAFT CASE STUDY REPORTS**. LBNL will revise the draft CASE Study reports for CEC Project Manager's review and comment and will incorporate CEC Project Manager's comments into the Final Draft CASE Study reports.

Task 6. Support for CEC CASE study proposals during CEC rulemaking:

LBNL will participate in a maximum of eight (4) CEC workshops or adoption hearings, and twenty (6) teleconferences, as requested by the CEC Project Manager, to assist with advocacy of proposed code enhancements and to gather comments on CEC Code change proposals.

Task 6.1. Presentation materials:

Prior to each CEC workshop, hearing, or teleconference call, LBNL will prepare support materials as requested by the CEC Project Manager. Support materials shall include, but not be limited to:

- CASE studies and summary presentations; and
- Ongoing research, analyses and status summary presentations.

DELIVERABLES/DUE DATES: **PRESENTATION MATERIALS**. LBNL will prepare draft presentation materials for CEC Project Manager's review and approval and will incorporate CEC Project Manager's comments into the final presentation materials.

Task 6.2 CEC workshop and summary report:

During the workshop, LBNL will present materials, participate in discussions and record significant issues presented by each stakeholder, significant questions, and outstanding issues. Following each CEC workshop, hearing or teleconference, LBNL will provide a written summary report to the CEC Project Manager. Summary report shall include, but is not limited to, links to the CEC web site where the workshop agenda and presentations are posted, information recorded (significant issues and questions) during the meetings, and recommended actions in response to questions and outstanding issues. LBNL will prepare draft responses to questions and issues under the direction of the CEC Project Manager. Responses shall include, but are not limited to:

- Performing additional analysis;
- Conducting additional market research;
- Developing alternative code revision language;
- Preparing communications memoranda, e-mail comments, or other materials;
- Conducting teleconferences or stakeholder meetings;
- Revising CASE Studies; and
- Gathering or developing other materials as needed.

DELIVERABLES/DUE DATES

1. **SUMMARY REPORT**: LBNL will provide summary report after each CEC workshop.
2. **RESPONSES TO QUESTIONS AND ISSUES**: LBNL will prepare draft responses for CEC Project Manager's review and approval, and incorporate CEC Project Manager's comments into the final responses to questions and issues.

Task 7. Review of Title 24 documents:

LBNL will review drafts of CEC Title 24 documents to ensure that CEC Code amendment proposals are correctly incorporated:

- 2008 Building Energy Efficiency Standards for Residential and Nonresidential Buildings (and related appendices);
- 2008 Nonresidential and Residential Alternative Calculations Methods Manual (and related appendices); and
- Residential Manual for Compliance with 2008 Energy Efficiency Standards for Low-Rise Residential Buildings (and related appendices).

Under the direction of the CEC Project Manager, LBNL will report the status of and describe needed changes to draft documents by performing the following:

- Conducting a detailed review of Title 24 documents focusing on text and diagrams related to code enhancements;
- Identifying and documenting inconsistencies between Title 24 documents and CEC CASE studies;
- Proposing edits in the CEC-required format;
- Attending up to five conference calls to discuss proposed edits with CEC staff;
- Providing edits to Title 24 documents that resolve inconsistencies; and
- Gathering or developing other materials as needed.

DELIVERABLES/DUE DATES: **PROPOSED REVISIONS TO TITLE 24**. LBNL will prepare proposed edits to Title 24 documents for review. LBNL will incorporate comments by the CEC Project Manager to prepare final proposed edits, and submit to CEC Project Manager and CEC staff. Schedule to be determined by CEC Project Manager based on CEC rulemaking schedule and other deadlines.

Task 8. Final CASE studies and estimated overall impacts:

Following adoption of the 2008 standards, LBNL will prepare a final CASE Study report documenting the initial proposal, any modifications throughout the process, and the final status of the proposal.

LBNL will update all sections of each Final Draft CASE Study to reflect all changes (for example, code language or savings estimates) resulting from stakeholder input during the CEC rulemaking process and differences in impact analyses.

DELIVERABLE/DUE DATE: **FINAL CASE REPORTS**. LBNL will submit each Final 2008 CASE Study to the CEC Project Manager for review and comment and shall incorporate comments into final document. Schedule to be determined by CEC Project Manager and LBNL.

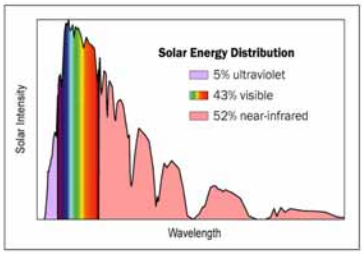
Custom-Bilt Energy Efficient Sustainable and Durable Roofs

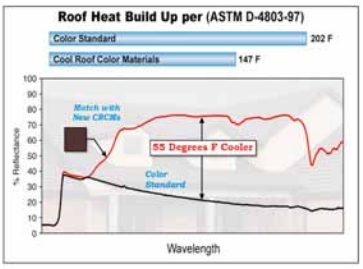
CUSTOM-BILT METALS
13950 Magnolia Avenue
S. El Monte CA 91733
Phone (626) 454 4850
Fax (626) 454 4785

COOL ROOF COLOR MATERIALS (CRCMs)

Most painted roofs today have a reflectance of about 5% to 20%, but special paint made using cool pigmented colors can give you a much higher reflectance of almost 60%. A roof covered by this special paint absorbs less solar energy and can save nearly 20% of your air conditioning costs.

BASF, FERRO Corp. and the Shepherd Color Company have developed a palette of Cool Roof Color Materials CRCMs that look dark in color even though they reflect most of the sun's energy. How can these dark roofs reflect as much or more energy than a white roof? The sun's radiation consists of ultraviolet, visible, and infrared energy. Our eyes can only see the visible region. The visible light that is reflected from an object determines the color of that object. White roofs reflect most of the visible light (which mixes together to look white to our eyes), but over half of the sun's energy is contained in the infrared region, which isn't visible to our eyes. Because we can't see this energy, we can reflect it away from the roof without changing the roof's color.





Advantages of Cool Roof Color Materials

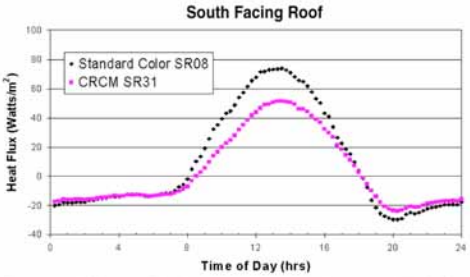
- Architectural appeal and durability
- Reflect more sunlight and stay cooler
- Lower utility bill for cooling the house
- Better fade resistance than standard colors

Architectural appeal and Durability

The national demand for painted metal roofs for homes increased three-fold over the past six years. Painted metal roofing is available in a wide variety of textures, colors, surface finishes, and formed profiles, See Custom-Bilt's photo gallery at their web site: (http://www.custombiltmetals.com/). Its finishes are colorful, inert, and do not pose a health risk. It is code compliant and tested for fire, wind, hail resistance and is non-combustible which reduces the spread of fire in and among buildings. CRCMs further protect the residence from external forest fires by reflecting the infrared energy away from the roof.

Reflect more sunlight and stay cooler

A demonstration site in Fair Oaks, California (suburb of Sacramento) has two pairs of identical homes being evaluated by LBNL and ORNL. Custom-Bilt had the one pair of homes of identical footprint roofed with painted metal shakes of the same color, one roof with CRCMs the other roof having standard color pigments. The field study continues to show the positive energy benefits of painted metal roofs. Measurements for September, 04 show the heat penetrating the south facing painted metal roof dropped 36% of that crossing the metal shake with conventional pigmented colors.



Painted Metal Shakes with and without CRCMs.

Lower utility bill for cooling the house

Because less heat penetrates the roof, the attic remains cooler and, in turn, the heat leaking into your air-conditioned home drops. A chocolate brown color roof with 30% reflective CRCMs decreases the consumed cooling energy by 15% of that used for a roof with standard chocolate brown color exposed in hot climates.

Better Fade Resistance

Over 10,000 hours of accelerated fluorescent (UV) exposure has proven the CRCMs more fade resistant simply because they reflect more light and are cooler than conventional pigmented products.

ORNL • Dr. William Miller • (865) 574-2013
LBNL • Dr. Hashem Akbari • (510) 486-4287

Attachment E

A Twenty-Seven Home Large-Scale Demonstration Showcasing Painted Metal Roofs with Cool-Pigmented Colors

Contact Persons: Tony Chiovare, Owner and CEO of Custom-Bilt Metals,
13940 Magnolia Avenue, Chino, CA 91710, Phone (909) 664-1500,
FAX (909) 664-1520, Email: Conniec@custombiltmetals.com

Robert Scichili, Color Specialist and Consultant for Custom-Bilt Metals,
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FAX (972) 231-2523, Email: RGScichili@AOL.com

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Hashem Akbari, Heat Island Group,
Lawrence Berkeley National Laboratory, Berkeley, CA 94720, Phone (510) 486-4287,
FAX (270) 638-2814, Email: H_Akbari@lbl.gov

Technology: Industry researchers, including those working with the Department of Defense, have developed novel complex inorganic color pigments that are dark in color but highly reflective in the infrared portions of the solar spectrum. Originally, paints with these pigments were used for military camouflage to match the visible and infrared reflectance of background foliage. However, the painted metal industry observed through testing that cool-pigments consisting of a mixture of chromic oxide (Cr_2O_3), ferric oxide (Fe_2O_3) and titanium dioxide would boost the solar reflectance of black polyvinylidene fluoride painted metal by a factor of 5 over that of conventional dark roofing. The increase in reflectance reduces the temperature of the painted surface, and the aesthetically pleasing dark roof reduces the cooling-energy demand of the building, which saves money.

Subsequently, Custom-Bilt Metals of El Monte, CA, Classic Products of Piqua, OH and other metal roof manufacturers have introduced several lines of painted metal roof products that take advantage of the cool-pigment technology. Tony Chiovare, CEO of Custom-Bilt Metals, stated that the additional cost of the cool-pigments is only about 5¢ per square foot of finished product, which researchers have shown will pay for itself easily within three years because of the building energy savings.

Goals: The California Energy Commission (CEC) wants the cool-pigment technology fully integrated in all roof products. However, rebates and or energy credits are needed to accelerate the market adoption of cool-pigmented metal, tile and asphalt shingles. The California utility companies want to see demonstrated the electrical energy savings per ton of air-conditioning capacity from which each utility can best determine realistic and fair rebates for consumers purchasing cool-pigmented roof products. Our primary objective then is to demonstrate in a large-scale residential subdivision the benefits of cool-pigmented roofs and the subsequent beneficial impact on the urban environment. The large-scale demonstration is more statistically significant than a one or two pair home demonstration and will provide the information needed for establishing rebates. Therefore our specific goals are to:

- Develop several large-scale demonstrations that show-case cool-pigmented painted metal, asphalt shingle, clay tile and concrete tile roofs.
- Collect whole house and air-conditioning power measurements for all homes participating in the large-scale demonstrations.
- Select a pair of homes at each demonstration site for collecting more detailed temperature and thermal measurements of the roof, attic, air-conditioner and living space. Collect high spatial resolution thermal infrared and visible reflectance data obtained from aircraft equipped with special scanners and map the surface temperature and reflectance characteristics of the large-scale demonstration to further assess the effectiveness of cool-pigmented roofs in mitigating heat island buildup.

Project: The California Energy Commission's Public Interest Energy Research program has two sister labs, Oak Ridge National Laboratory (ORNL) and the Lawrence Berkeley National Laboratory (LBNL) working with pigment colorant researchers and roof manufacturers to make cool-pigmented roof products a market reality by 2006. LBNL has developed a cool-pigment database containing a palette of visibly dark yet highly reflective colors. ORNL is demonstrating the potential energy savings of existing cool-pigment technology at two- and four-house demonstrations in Fair Oaks, Redding and Martinez, California. The CEC and industry are very encouraged by the collaborative work and now want to go the next step to fully implement the cool-pigment technology in the state of California.

Walt Ferguson Construction has asked Custom-Bilt Metals to supply painted metal roofs for a new subdivision being built in Yucaipa, California. Some twenty-seven homes are proposed for the new subdivision, and each house has a footprint of about 2,500 square feet. We propose to install energy management systems (EMSs) on an exterior wall of each home, and monitor the whole- house and air-conditioning power consumed by the twenty-seven homes. The EMSs will also control the thermostat settings in a pair of fully instrumented homes. We will instrument the one pair to measure the temperatures at the roof surface, on the underside of the attic deck, in the mid-attic air, at the top of the insulation, on the interior ceiling sheet rock surface, and inside the building. Relative humidity in the attic air and the residence will also be measured. Heat flux transducers will be embedded in the sloped roofs and the attic floor to measure the roof heat flows and the building heat leakage. The air-conditioner and ancillary building power demands will also be recorded to document whole building services and help gauge the cost

savings for reflective roofing. A fully instrumented meteorological weather station will be setup at one of the two pair of homes, and will collect the ambient dry bulb temperature, the relative humidity, the solar irradiance, and the wind speed and wind direction. The weather stations will also serve as a command center acquiring power measurements for all twenty-seven homes using wireless technology.

The services of NASA's Stennis Space Center shall be acquired for obtaining thermal infrared and visible data from their Advanced Thermal and Land Applications Sensor (ATLAS) scanner flown aboard a Lear 23 jet aircraft. The ATLAS can collect data ranging from 2 to 20 meters in resolution, and will provide mapping of the surface temperature and reflectance of the large-scale demonstration. The data can then be used for surface parameterization of meteorological and air quality models for assessing the effect of cool-pigments in mitigating urban heat which in turn reduces carbon dioxide emissions and smog.

Roles: Custom-Bilt Metals will contract with Walt Ferguson Construction to sell and install panted metal roofs for the new subdivision in Yucaipa, California. ORNL will provide and install the EMSs on an exterior wall of each home. ORNL will also provide a central station for collecting the weather data as well as power measurements from the twenty-seven homes using wireless setup. LBNL will use the urban surface temperature and reflectance mapping in models to better quantify the ancillary energy savings derived for cool-pigmented roofs.